Model E-140

Count Rate Meter Technical Manual

SALES

Eberline

A subsidiary of
Thermo Instrument
Systems Inc.

GENERAL INFORMATION

Instruments for repair or calibration should be packaged, marked, or otherwise prepared in accordance with good commercial practices and shipped F.O.B. destination freight prepaid to one of the Eberline facilities below.

Repair and Calibration Facilities

Eberline Instrument Corporation
504 Airport Road
Santa Fe, NM 87504-2108
Attn: Western Service Center
(505) 471-3232
1-800-274-4212

Eberline Instrument Corporation
312 Miami Street
West Columbia, SC 29169
Attn: Eastern Service Center
(803) 822-8843
1-800-234-4212

Normal turn-around time for repair (Eberline instruments) is fifteen working days.

Normal turn-around time for calibration (Eberline instruments) is seven working days.

Prices

Certified calibration (Eberline portable instruments)(2 points/range)	
Unit and one probe	$85.00
Second probe	40.00
Third or fourth probe (Limited to 4 probes per instrument)	20.00
Certified calibration (other manufacturer's portable instruments)	85.00
ALPHA-3, ALPHA-5, AMS-3, HFM's, Portal Monitors, RM-22, SAM-2, WLM-1A, ESP-2 6112B, 6112D (certified calibration)	135.00
RGM-2 (certified calibration)	385.00
RGM-3 (certified calibration)	220.00
As found readings on any of the above, a charge of 50% of calibration rate shall be made.	
Calibrate "non-removeable" contaminated instruments	QUOTE
Services Contracts (Eberline equipment)	QUOTE
Technical Specification writing and Consultation	QUOTE
Service Engineer at Customers Site	$780.00/day plus expenses at cost.
-Over 8 hours or Saturday and Sunday	147.00/hr
-Eberline Holidays	195.00/hr
Consulting	835.00/day
Repair rate (plus calibration and parts at list price)	77.00/hr
Repair "non-removeable" contaminated instruments	77.00/hr
Expediting Fee	50.00/ instrument

Note: Repair and Calibration time on non-Eberline instruments is subject to availability of parts and literature for the specific instrument.

Repair or Calibration Warranty

Eberline warrants to replace or repair, at its option, any repaired products or replaced parts thereof (excluding tubes, crystals, batteries and normal consumables) which are found defective in material or workmanship within ninety (90) days from date of repair or the balance of the new purchase warranty, whichever occurs later. Instruments calibrated by Eberline are warranted to be within specified limits at time of shipment. In the event of calibration error, Eberline will again calibrate the instrument without charge to the instrument owner. The aforesaid warranty does not cover life-end failure of components and will be voided if repair has been attempted by other than seller's authorized personnel. In no event shall Eberline be liable for consequential or special damages, transportation, installation, adjustment, work done by customer or other expenses which may arise in connection with such defective product or parts.

Exclusion of Warranties and Limitation of Liability

The foregoing warranty is expressly made in lieu of any and all other warranties express or implied including the warranties of merchantability and fitness for a particular purpose. Under no circumstances shall seller be liable for any indirect, special, incidental, or consequential damages to customer or to any third party.

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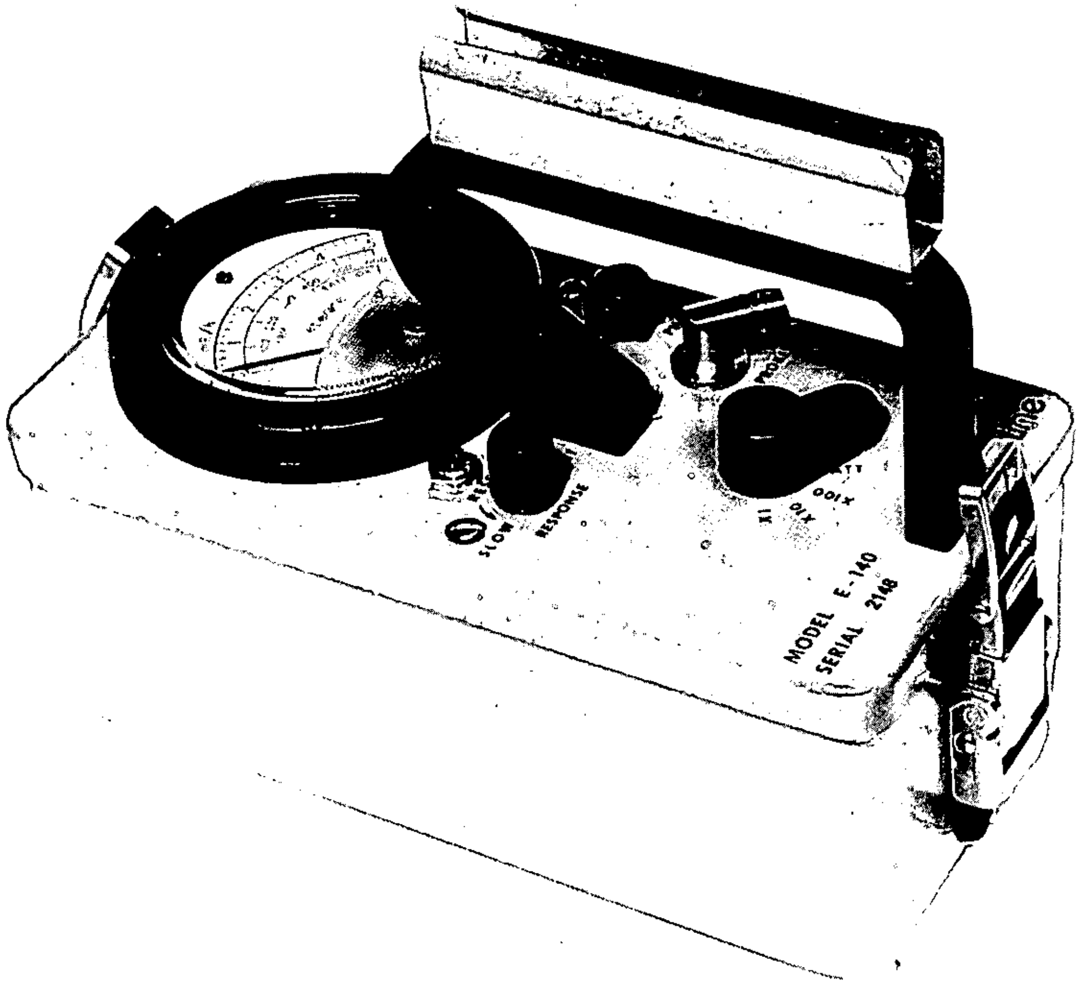


Figure 1-1. Model E-140

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The Model E-140 is a small, lightweight Geiger counter for the detection and measurement of gamma or beta radiation. A 900 V Geiger-Mueller (GM) detector (Eberline HP-270, HP-190, etc.) is required for operation.

Two "D" cell size batteries power the instrument, and special circuitry is incorporated to conserve battery life. The battery condition may be checked by a front panel control. The radiation intensity is read out on a large, easily read meter with a linear scale. Three switch-selected ranges give full scale sensitivities of 600, 6k and 60k counts per minute (0.5, 5, 50 mR/h). The response time of the meter is continuously adjustable, and the reading may be brought to zero at any time by the reset control.

The count-rate-to-dose-rate relationship on the meter face is the nominal relationship for an Eberline HP-270 in ^{137}Cs gamma field.

A phone output is provided for the use of earphones, an Eberline Model SK-1 speaker, or for counting events with a scaler.

B. SPECIFICATIONS

1. Indicator

a. Visual

(1) Range: Switch controlled multipliers of 1, 10, and 100, yielding 600, 6k and 60k counts per minute (cpm) full scale or 0.5, 5, and 50 mR/h.

(2) Response Time: Continuously adjustable by the *RESPONSE* control from 2 seconds to 10 seconds, measured to 90 percent of the final reading.

(3) Linearity: Within ±5 percent of full scale, typically ±2 percent of full scale.

(4) Battery Dependence: Calibration shifts less than 10 percent with battery voltage change from 3 to 2 V (new batteries to end point).

b. Aural

(1) Connector: Switchcraft No. 5501MP.

(2) Signal: One pulse for each event counted. Negative 2.5 V (battery voltage) capacitively coupled.

2. Power

a. Battery Complement: Two each "D" size batteries of any type with voltage between 1.0 and 1.6 V per battery.

b. Battery Life: Depends on battery type, age, and temperature. Nominal life with new batteries near room temperature is:

Type	Life
Carbon-Zinc	300 hours
Alkaline	500 hours
Mercury	700 hours
Nickel-Cadmium (Single Charge)	200 hours

3. Environmental

a. Temperature: The instrument is operational from -40 °F to +140 °F (-40 °C to 60 °C) with a typical temperature coefficient of reading less than 0.1 percent per °F (0.18 percent per °C).

The battery type used limits the low temperature performance because of terminal voltage decrease and internal impedance increase. For prolonged operation at low temperatures the following criteria is suggested:

Battery Type	Usable To
Mercury	+32 °F (0 °C)
Carbon-Zinc	0 °F (-18 °C)
Alkaline	-40 °F (-40 °C)
Nickel-Cadmium	-40 °F (-40 °C)

4. Mechanical

a. Size:
Length: 8 ½ inches (21.6 cm)
Width: 3 ⅞ inches (9.8 cm)
Height: 6 ⅞ inches (17.5 cm) including handle and probe holder

b. Weight: 3 pounds, 6 ounces (1.53 kg) less probe with Alkaline batteries.

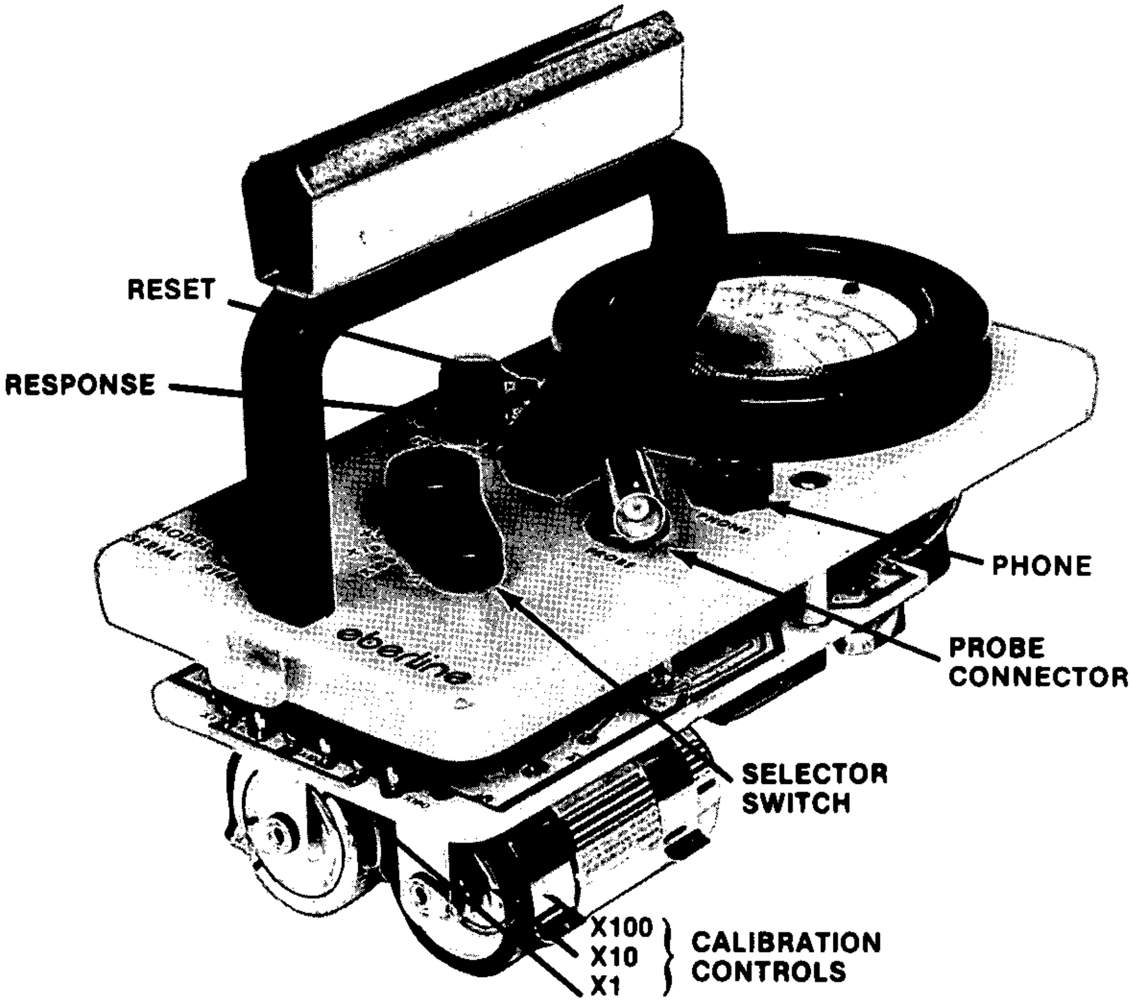


Figure 2-1. Internal and External Controls

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. External (See Figure 2-1)

a. Switch: Five-position rotary switch that turns the instrument *OFF,* checks the battery *(BATT)* condition, and selects scale multipliers of *X100, X10* or *X1.* This number must be multiplied by the meter indication to obtain the proper reading.

b. *RESPONSE:* Controls the response time of the meter to the most desirable compromise between speed and fluctuation for the particular usage.

c. *RESET:* Discharges the integrating capacitor, bringing the meter reading to zero rapidly.

d. *PHONE:* Pulse output for use with an earphone, speaker, or external scaler. The mating connector is Switchcraft No. 5501F (EIC COAF11(0) or equivalent.

e. *PROBE:* Connection to the hand probe. BNC series coaxial.

2. Internal (See Figure 2-1)

a. Calibration Controls: One control for each range which individually calibrates that range to agree with the input pulse rate.

B. PREPARATION FOR USE

1. Inspection

The instrument should be checked for physical damage.

2. Connections

Connect the probe cable to the probe connector.

C. USING THE INSTRUMENT

1. Starting

Turn the switch to the *BATT* check position. The meter should indicate within the *BATT OK* area.

2. Operation Check

Place a check source in a repeatable position adjacent to the detector and move the switch to a range that gives an upscale reading. Note that the reading is sensitive to the position of the source. The reading may be recorded for future reference.

Push the *RESET* button and the reading should drop to zero rapidly, then climb back to source reading when the *RESET* is released. The *RESPONSE* may be adjusted to get the most desirable compromise between speed of response and meter fluctuation.

3. Interpretation of Indications

The meter reading must be multiplied by the scale factor to obtain the proper number. The fluctuation of the meter is normal and is caused by the random nature of radioactive decay.

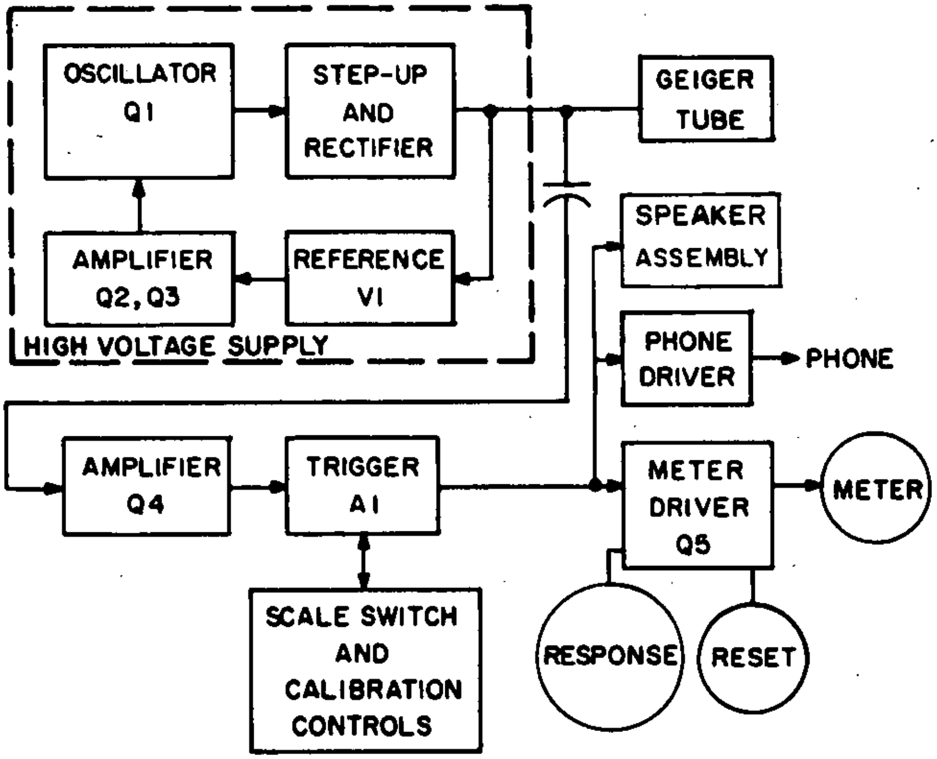


Figure 3-1. System Block Diagram

SECTION III
THEORY OF OPERATION

A. GENERAL (See Figure 3-1)

The high voltage supply develops +900 V, which is applied to the Geiger tube, giving it the proper operating voltage. When radiation reacts in the Geiger tube, negative pulses are generated. These pulses are coupled into the amplifier where they are amplified. They are then coupled to the trigger circuit where they are converted to standard size pulses of power. These standard pulses are applied to the meter driver which converts them to standard pulses of current, averages this current, and drives the meter. Thus, the meter deflection is proportional to the average rate of radiation at the Geiger tube.

B. FUNCTIONAL THEORY (See Figures 3-1 and 6-1)

1. High Voltage Supply

The oscillator transistor Q1 drives T1 primary and gets its feedback from T1's red-orange winding. The voltage is stepped up by T1's secondary, rectified, filtered, and applied to V1. V1 regulates at 900 V. The current through V1 is sensed by Q2, amplified, and used to control the current through Q3. The current through Q3 controls the bias level of the oscillator Q1. This tends to hold the current through V1 to a constant value regardless of battery voltage. This greatly extends battery life.

2. Amplifier

Q4 amplifies and inverts the negative input pulses from the detector. It is biased just into cutoff so its output is near 0 V. A pulse turns it on and the resulting positive output pulse starts the trigger circuit.

3. Trigger

Integrated circuit A1 is connected to operate as a monostable multivibrator whose pulse width is controlled by the R-C time constant between its pins 7 and 3. This time constant is established by the setting of S1B (scale selection) which selects a particular R and C. The calibration controls form the R for each scale, making the pulse width continuously adjustable for calibration.

When the trigger is initiated by the pulse from Q4, the output at pin 6 goes positive and holds until the predetermined time (R-C) elapses.

4. Meter Driver

The driver Q5 is normally off so no current flows through M1. When the trigger is on, Q5 is turned on and current flows. The amount of current is determined by the voltage on the base of Q5 and R15. The length of time that current flows is determined by the pulse width of the trigger. This (current times time) forms a certain charge which is transferred to C9 for each event counted. C9 discharges through M1, yielding a certain average current dependent on the rate of input pulses. Changing the pulse width of the trigger (that is, changing scales or calibration pot setting) changes the average current for a given input pulse rate. This allows the meter to be calibrated to read in cpm from the detector.

The response time of M1 is controlled by the R-C time constant of C9 and R16, the *RESPONSE* control. With R16 set to low resistance the time constant is fast, and at high resistance it is slow.

5. Phone Driver

Q6 amplifies and inverts the output pulse from the trigger, yielding a large amplitude negative going pulse which is capacitively coupled to the *PHONE* connector.

SECTION IV
MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. Printed Circuit Board

The PC board and cover may be separated for troubleshooting. Proceed as follows:

a. Remove the batteries to prevent electrical damage during disassembly.

b. Remove the knob and mounting nut from the scale switch.

c. Remove the two screws that go through the front cover into the threaded spacers.

d. Separate the board and cover without putting undue stress on the wires.

e. Reassemble in reverse order of disassembly.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.

2. Replace the batteries when their check reading is below the acceptable level.

3. Remove the batteries if the instrument is to be inactive for a long period (over six months).

C. CALIBRATION

For maximum accuracy, the instrument should be calibrated under the same conditions as it will be used. Refer to Section I, B. for effects of battery voltage and temperature. Proceed as follows.

1. Capacitively couple a pulse generator into the probe connector using a capacitor with a 1 kV or higher voltage rating. The pulse generator must have a negative pulse with approximately 350 mV amplitude and frequency covering the instrument range.

2. Adjust the pulse generator frequency to correspond with approximately three-quarter scale meter reading and adjust the calibration control for the range selected until the meter agrees with the frequency. Repeat for each range *(X1, X10, X100)*. If using the mR/h range, place the detector in a field of approximately three-quarters of full scale and adjust for the proper reading.

D. TROUBLESHOOTING

Typical voltages and waveforms are given on the schematic Figure 6-1, and component locations are shown in Figure 6-2.

Voltages are measured with a 20,000 Ω/V or greater voltmeter, except the 900 V point. An electrostatic voltmeter or HV probe with input impedance of 1000 MΩ or greater should be used to check the 900 V; however, if these are not available, a conventional meter may be used if loading is accounted for.

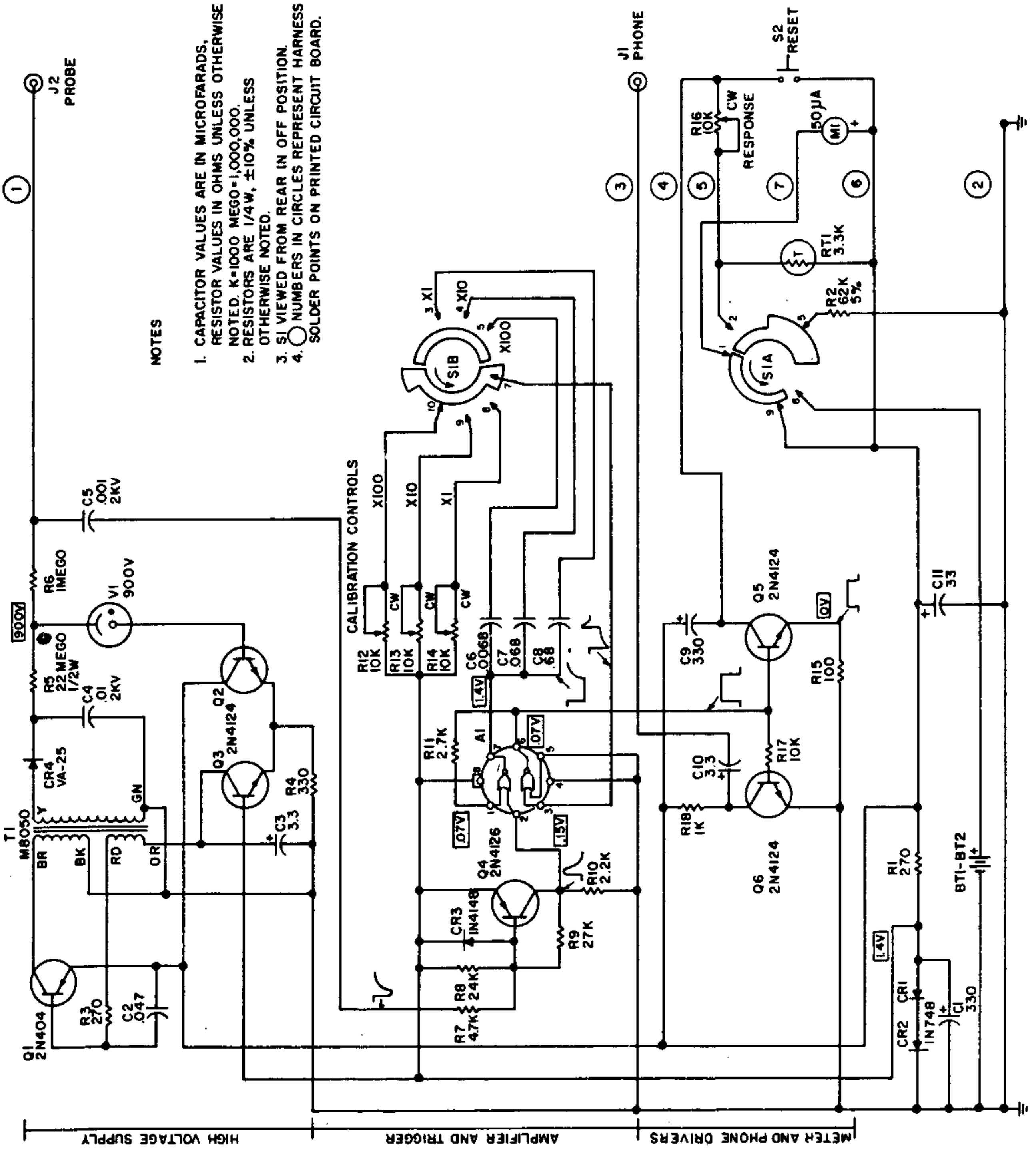
SECTION V
PARTS LIST

The following table lists the electronic and mechanical items incorporated in the E-140 and should contain any part necessary for normal repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
A1	Integrated Circuit	RTL Dual NOR Gate	Motorola MC810G	ICRTC0810G (2)
BT1, BT2	Battery	Alkaline "D" Cell	Eveready E95 or equivalent	BTAK3 (4)
	Battery Holder Kit			BTBH4 (5)
C1, C9	Capacitor	330 µF, 10%, 6 V	Sprague 150D or equiv.	CPTA331M3D (1)
C2	Capacitor	0.047 µF, 10%, 100 V	Sprague 225P47391WD3	CPPF473P3P (2)
C3, C10	Capacitor	3.3 µF, 10%, 15 V	CS13	CPTA335P3H (5)
C4	Capacitor	0.01 µF, 20%, 1.6 kV	Centralab DD-16	CPCE103PXV (3)
C5	Capacitor	0.001 µF, 10%, 3 kV	Centralab Type DD-30	CPCE102P3Y (7)
C6	Capacitor	0.0068 µF, 10%, 80 V	Sprague 192P6829R8	CPPF682P3O (9)
C7	Capacitor	0.068 µF, 10%, 80 V	Sprague 192P6839R8	CPPF683P3O (7)
C8	Capacitor	0.68 µF, 10%, 35 V	CS13	CPTA684P3L (0)
C11	Capacitor	33 µF, 10% 10 V	CS13	CPTA330M3F (1)
CR1, CR2	Diode, Zener	3.9 V	1N748	CRZR1N0748 (3)
CR3	Diode		1N4148	CRSI1N4148 (7)
CR4	Diode	High voltage		CRSIVA0025 (3)
J1	Phone Jack	Male	Switchcraft No. 5501MP	COAF12 (9)
J2	Connector (Probe)	BNC (Angle)	UG-1098/U	CXBN9 (0)
	Jack Cover	Black Plastic	Rob Roy M165-B	COHD18(0)
M1	Meter	0-50 µA	Triplett No. 321HR	MTPA6 (8)
	Meter Face	10472-B58		ZP10472058 (6)
Q1	Transistor	PNP Ge	2N404A	TRGP2N404A(2)
Q2, Q3, Q5, Q6	Transistor	NPN Si	2N4124	TRSN2N4124 (2)
Q4	Transistor	PNP Si	2N4126	TRSP2N4126 (8)
R1, R3	Resistor	270, 5%, 1/4 W		RECC271B22 (7)
R2	Resistor	62k, 5%, 1/4 W		RECC623B22 (9)
R4	Resistor	330, 5%, 1/4 W		RECC331BB2 (9)
R5	Resistor	22M, 5%, 1/2 W		RECC226B23 (0)
R6	Resistor	1M, 5%, 1/4 W		RECC105B22 (7)
R7	Resistor	4.7k, 5%, 1/4 W		RECC472B22 (1)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R8	Resistor	24k, 5%, 1/4 W		RECC243B22 (6)
R9	Resistor	27k, 5%, 1/4 W		RECC273B22 (3)
R10	Resistor	2.2k, 5%, 1/4 W		RECC222B22 (0)
R11	Resistor	2.7k, 5%, 1/4 W		RECC272B22 (5)
R12, R13, R14	Potentiometer	10k	CTS (Type X201R103B) No. RR9167	PTCC103B02 (0)
R15	Resistor	100, 5%, 1/4 W		RECC101B22 (6)
R16	Potentiometer	10k, 20%	CTS Series 3000	PTCC103B43 (1)
R17	Resistor	10k, 5%, 1/4 W		RECC103B22 (2)
R18	Resistor	1k, 5%, 1/4 W		RECC102B22 (4)
RT1	Sensistor	3.3k, 10%, at 25°C	Type TM-1/4	RETS332BX2 (5)
S1	Switch	Scale (Rotary)		SWRO27 (9)
S2	Switch	*RESET,* NO	Grayhill 30-1	SWPB5 (8)
T1	Transformer		Microtran M7120	TFHV2 (0)
V1	Regulator Tube	900 V	Victoreen GV3B-900 or 5841 (10450-B29)	TUVR900 (4)

SECTION VI
DIAGRAMS



NOTES

1. CAPACITOR VALUES ARE IN MICROFARADS, RESISTOR VALUES IN OHMS UNLESS OTHERWISE NOTED. K=1000 MEGO=1,000,000.
2. RESISTORS ARE 1/4W, ±10% UNLESS OTHERWISE NOTED.
3. S1 VIEWED FROM REAR IN OFF POSITION.
4. ◯ NUMBERS IN CIRCLES REPRESENT HARNESS SOLDER POINTS ON PRINTED CIRCUIT BOARD.

Figure 6-1. General Schematic of Model E-140 (10550-C04F)

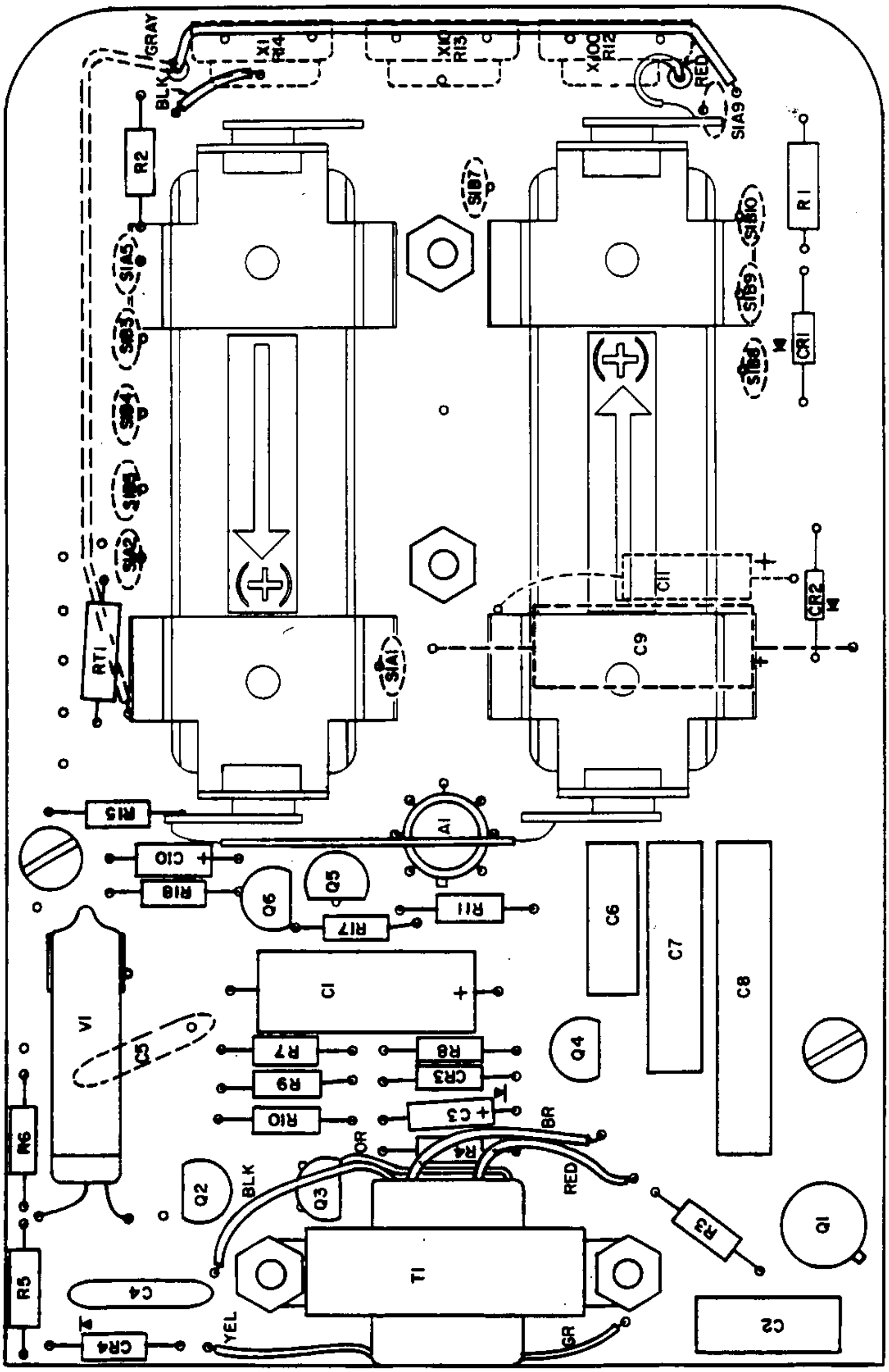


Figure 6-2. Circuit Board Component Layout of Model E-140 (10550-C12) A